Argonne NATIONAL LABORATORY

PHY Seminar

Physics Division Seminar

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Nuclear Physics with Neutron Star Mergers: the Spectacular Case of GW170817

Host: Paul Reimer

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On August 17th last year, the LIGO/Virgo collaboration detected gravitational waves from a new type of system: a binary neutron star merger (NSM). Two seconds later, a short gamma-ray burst (GRB) was observed, allowing accurate localization and follow-up observations across the entire electromagnetic (EM) spectrum, from high-energy gamma-rays to radio. Optical and infrared observations of this event detected a new type of transient – kilonova, powered by radioactivities of freshly synthesized *r*-process elements. This event and potential similar events in the future will allow us to see the *r*-process "in-the-making" and constrain nuclear physics in extreme regimes not accessible in laboratory or via pulsar observations. With more detections we might be able to finally resolve the mystery of the main r-process production site.

I will present an outline of a new multiphysics model, developed at LANL, which links kilonova to the properties of ejected material, such as mass, velocity, orientation and, most interestingly, nuclear composition. The key sensitivity in kilonova modeling is the nuclear heating and thermalization of generated energy, which in turn depends on the nuclear structure in the neutron-rich regime, potentially accessible to FRIB. The composition and heating are computed with WinNet *r*-process network and passed to multidimensional radiative transport code SuperNu to synthesize optical/infrared spectra with detailed composition-dependent atomic opacities. For the case of GW170817 the ejecta clearly separates itself into two distinct components, in line with predictions of numerical relativity. Two-dimensional character of our model allows us to infer approximate orientation of the system. Using nucleosynthesis network, we can robustly constrain neutron richness of the ejecta. In the future, advances in FRIB together with more detections, will tighten such constraints and impact current uncertainties in nuclear structure, for example models of nuclear mass and fission. Finally, I will briefly discuss other potential implications, such as those for the nuclear equation of state.